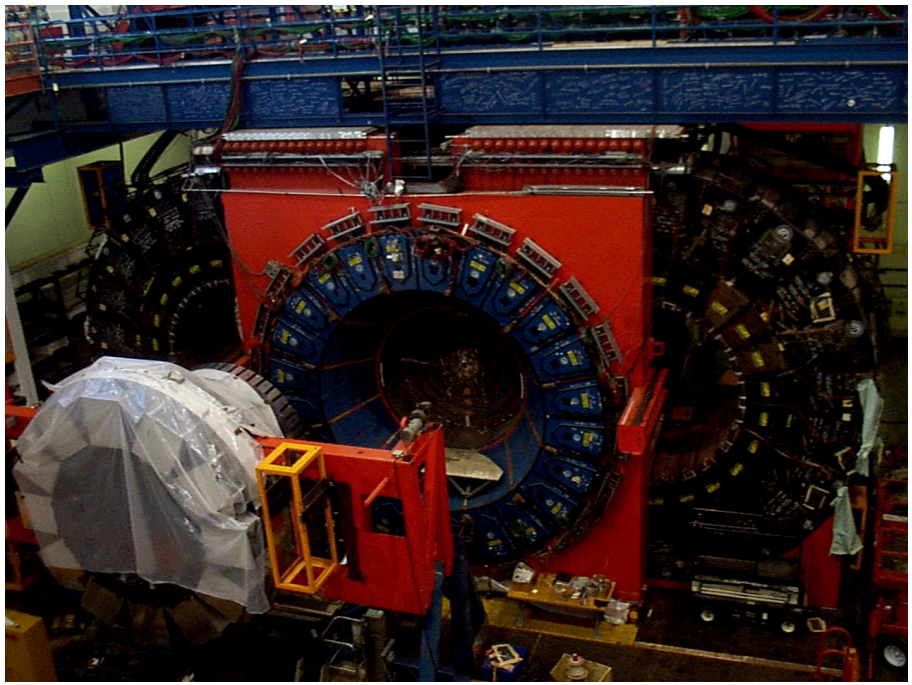
CDF Central Preshower Detector Upgrade for Run IIb

Joey Huston

Michigan State University

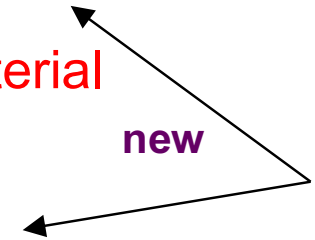
Preshower basics

- Central preradiator (CPR) lies behind 1.1 X_o of dead material (solenoid coil) and in front of EM calorimeter
- Next to CPR are more gas chambers, Central Crack Energy Detectors (CCR)
- CDF preshower used in >100 papers, about 1/2 of all Run I publications, including
  - Higgs searches
  - Sin(2β)
  - High p_T photons
  - Top quark mass



A New CPR for Run IIb

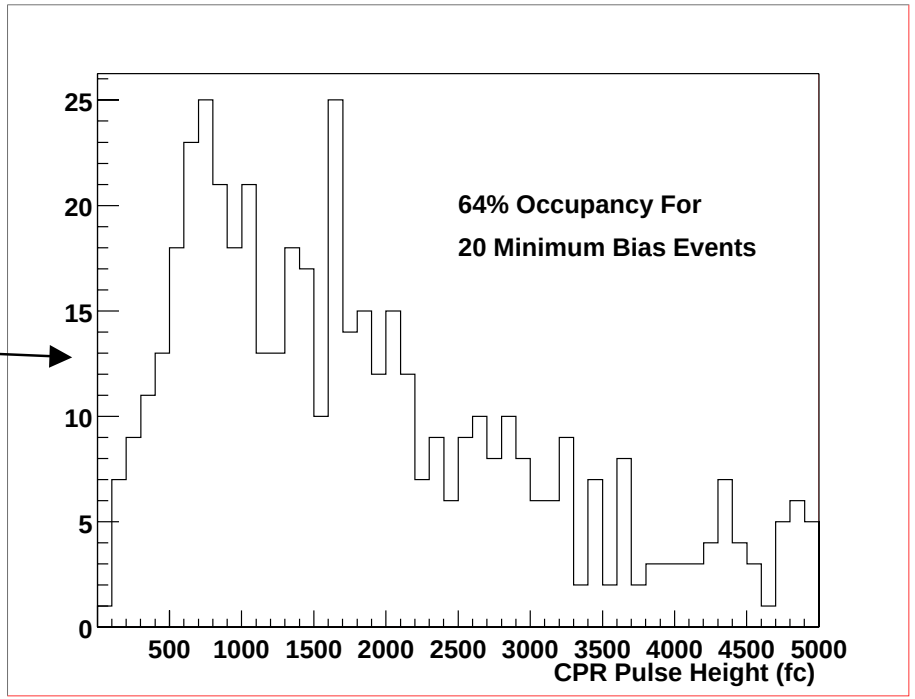
- Current/potential uses for a CPR
  - improving electron identification (factor of 3 in Run 1)
  - separating single photons from meson backgrounds (crucial for high E_T photons in Run I)
  - improving electron and photon resolutions by correcting for dead material
  - estimating the energy deposited in the EM calorimeter by charged hadrons



- Reasons for replacing the one we have
  - CPR is a slow wire chamber that integrates over several crossings and has relatively poor segmentation; this will lead to very high occupancies in Run IIb
  - current CPR segmentations makes it difficult to use in more sophisticated analyses, such as improving jet resolutions
  - with 15 fb^{-1}, the CPR will have integrated 0.15C/cm
  - thin gas layers in CPR and CCR have worse energy resolution than scintillator

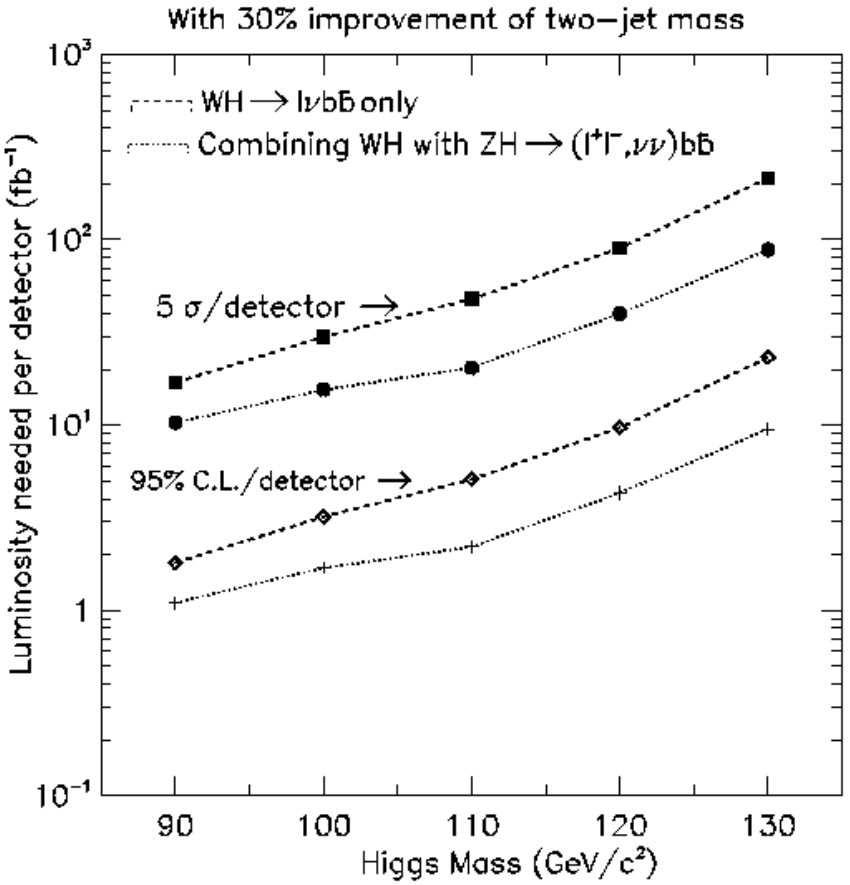
Occupancy Issues

- Current CPR is a slow wire chamber
- Based on early results from Run II, appears that integrating over 4 crossings may be necessary
- If peak Run IIb luminosities reach $6X10^{32}$, with 108 bunches and 132 ns spacing, then 5 MB events/crossing and current CPR will see 20 minimum bias events
  - occupancy of 64%
- If peak Run IIb luminosities reach $2X10^{32}$, but with 36 bunches and 396 ns, then 6 MB events/crossing and current CPR will see 12 MB events
- **Proposed detector will reduce occupancy by overlapping MB events by more than X10**
  - improving detector speed
  - improving detector segmentation



More Physics Motivation: CPR

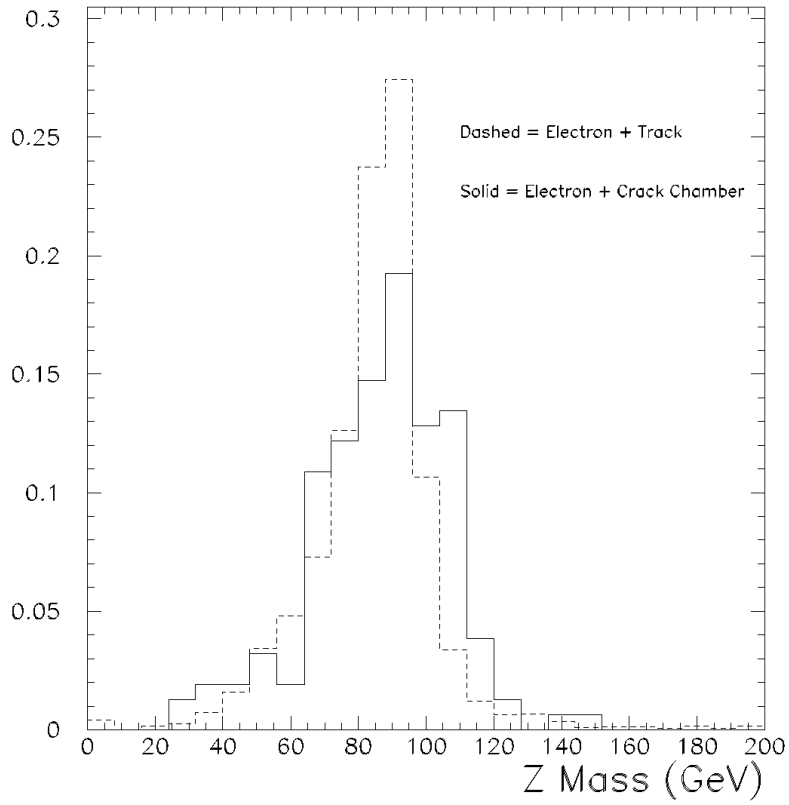
- Higgs physics
  - High p_T electron ID
  - Soft electron b-tagging
    - useful for the loose b-tag of a double tag
    - useful for neutrino corrections
  - Improving jet energy resolution (for H->bbar)
    - one of main challenges of energy flow algorithms is estimating fraction of track energy deposited in EM calorimeter
  - Photon energy resolution corrections



More Physics motivation: CCR

- Also useful for new physics searches involving photons and missing E_T
- Can tag photons hitting the crack which cause missing E_T
- Can be added for an additional 6% of the total cost, and installed at same time as CPR

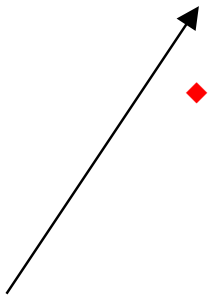
Example from Run I of crack tagging, in this case the second leg of a Z decay



Design for a new CPR

- Limited budget for Run IIb upgrades necessitates a limited budget for the CPR upgrade
  - existing electronic channels for current CPR and CCR channels will be re-used
    - determines channel count
    - actually improve usage of existing electronics
  - same 16-channel phototube (Hamamatsu R5900) as CDF endplug preshower and shower max will be used
    - 16 channels with pixel size of $4.5X4.5mm^2$
    - 4 MAPMTs/wedge for a total of 192
    - make use of experience and test stations

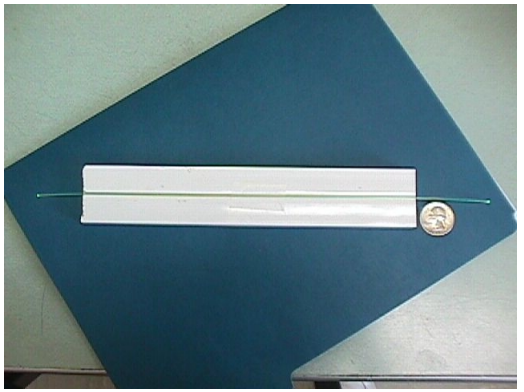
- Basic design of new CPR involves scintillator strips, read out by WLS fibers embedded in a groove in one surface of the scintillator
- Several options for scintillator (major decision path)
  - MINOS design; they are extruding 700,000 m of these strips
  - scintillator purchased form Bicron
  - scintillator produced by Dubna
  - require >~ 5 photoelectrons/mip
    - MINOS gets 10 pe/mip
    - Dubna scintillator of similar quiality but 2 cm thick instead of 1 cm, so expect more light



current favorite

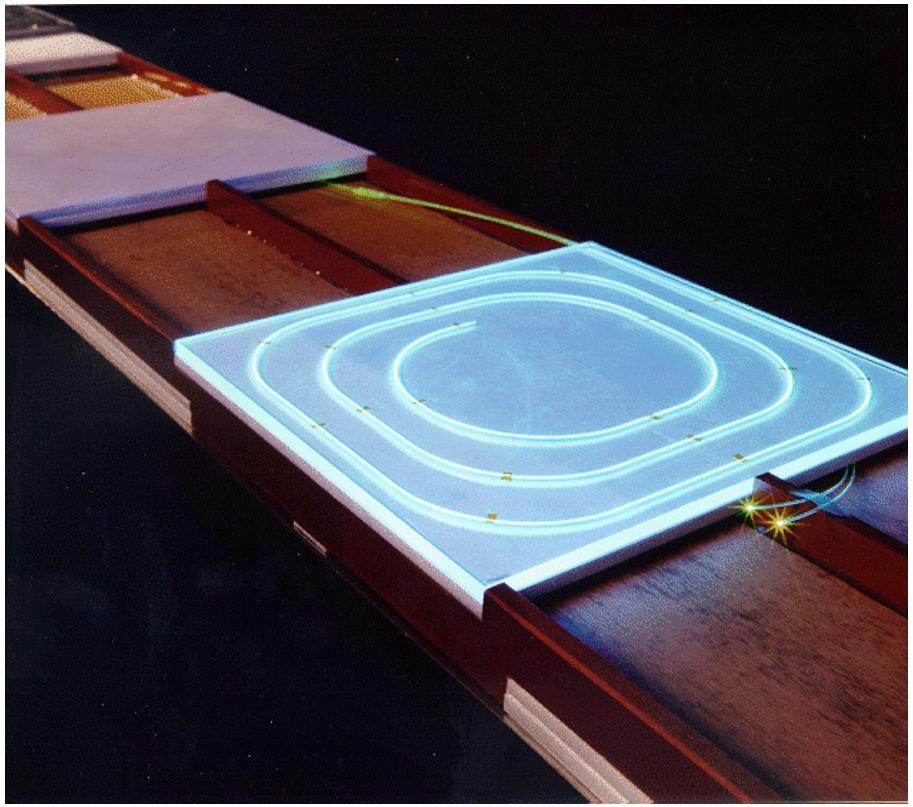
Scintillator Options

- Dubna scintillator
  - used for some of CDF muon counters
  - enough for CPR2 counters sitting in warehouse in Dubna currently (2 cm thickness)
  - sheets would be machined and grooved at Fermilab using facilities in Lab 8
- Bicron scintillator
  - commercial product with proven light yield
  - again, would buy sheets and have them grooved and machined at Fermilab
  - in any case, will use for crack scintillator
- MINOS is extruding 700,000 m of scintillator strips
  - 4.1 cm wide, 1 cm thick co-extruded with TiO2 coating
  - Cost is basically free, but width is not well-matched to preferred segmentation…and requires much greater length of WLS fiber, so total cost not much different



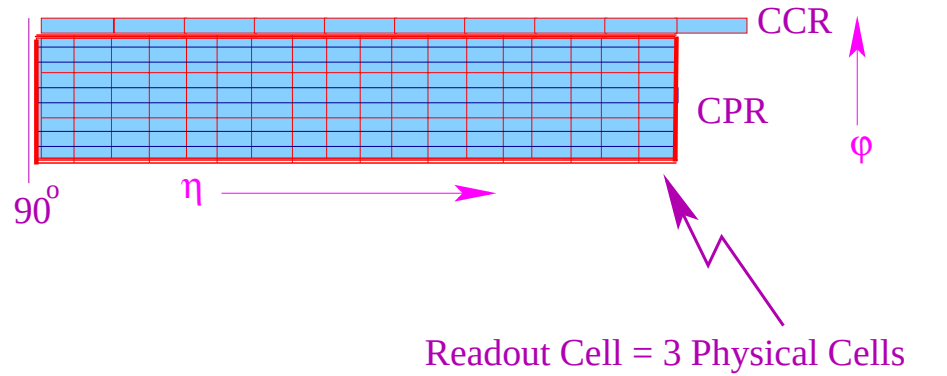
Bicron/Dubna

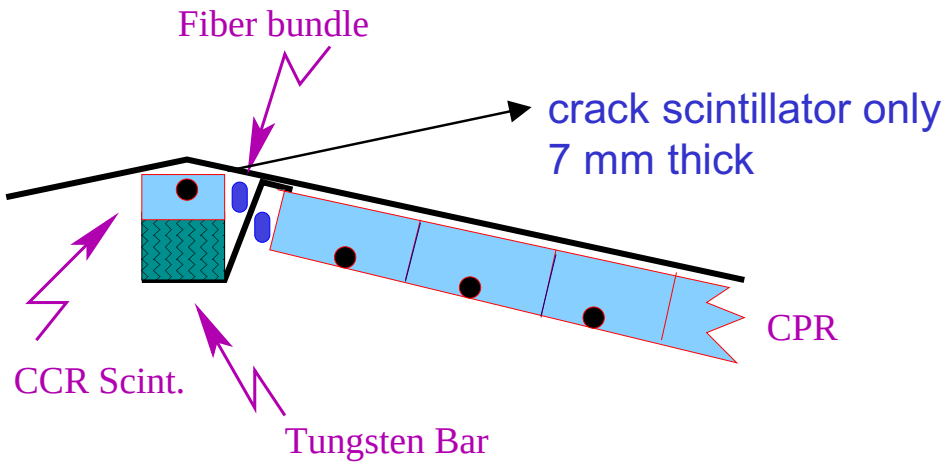
- With either Bicron or Dubna, there is more flexibility as to what type of groove to cut in the scintillator



CPR2 Design

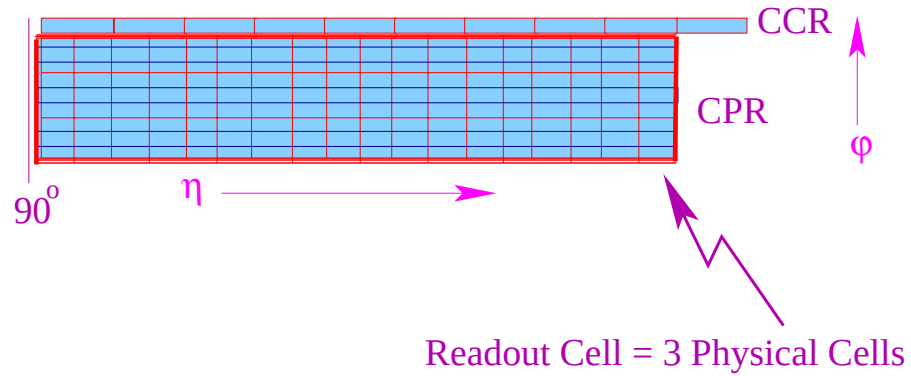
- New CPR will be placed in same space currently occupied by old CPR and CCR
- Basic design involves scintillator strips, segmented in η and ϕ, read out by WLS fibers
  - scintillator for each wedge assembled into a 'pizza pan' similar to endplug upgrade
  - WLS fibers routed through grooves in plastic layer underneath
  - glued into optical connectors at high |η| end
  - optical cables will be routed from connectors through the gap between central and endwall calorimeters to back of each central wedge
  - light signals will be coupled to pixels of MAPMT's

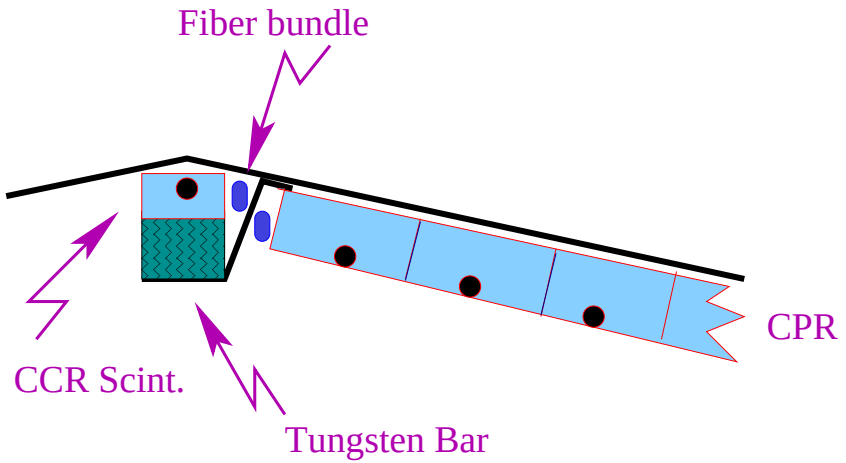




CPR2 Design

- Reusing existing electronics implies 64 channels available
  - modification of SMQIE/SQUID electronics not required
- One possible design would retain 10 CCR channels and allocate 6 channels to each of 9 fiducial calorimeter towers
  - 2X3 ($\Delta\eta X\Delta\phi$)
  - with this configuration, tower-based information could be used in optimized jet resolution algorithms
  - could overlap panels to provide 11 ϕ bins per wedge, at the expense of a larger occupancy
    - will be studied early in Run IIa





CPR2 organization

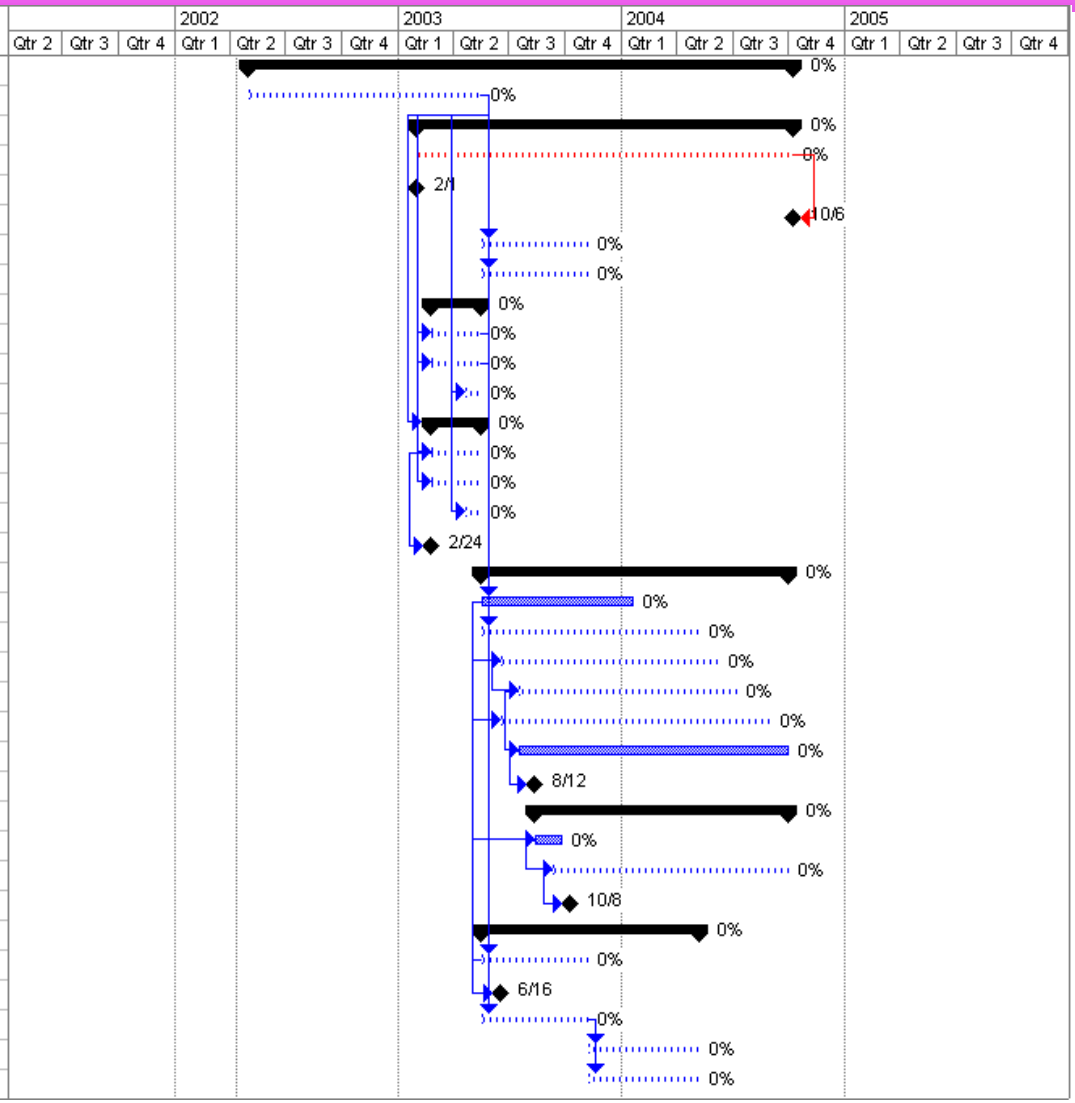
- 2 co-leaders
  - Joey Huston Michigan State
  - Steve Kuhlmann Argonne
- Participating groups
  - Argonne National Laboratory
  - Michigan State University
  - Rockefeller University
  - INFN Pisa
  - Tsukuba University

Much of the cost of this upgrade will come from foreign sources

- Basic division of tasks
  - Argonne
    - Final assembly/testing
  - Michigan State
    - WLS pigtails
    - Optical cables
  - Rockefeller
    - Software/simulation
  - INFN Pisa
    - HV supplies and cables
  - Tsukuba
    - PMT testing
  - Fermilab
    - Cutting/grooving of scintillator

Schedule

ID	Task Name
1	**Central Preshower**
2	Research and Development
3	**Procure parts**
4	Phototubes and bases
5	First phototube order placed
6	Final phototubes arrive
7	Electronics Transition Card
8	HV Supplies and cables
9	**CPR Detector parts**
10	Scintillator (JINR)
11	Optical Fibers and Connectors
12	Sheet metal and misc. supplies
13	**CCR Detector parts**
14	Scintillator (JINR)
15	Optical Fibers and Connectors
16	Sheet metal and misc. supplies
17	Scintillator and fiber orders placed
18	**CPR Detector Assembly**
19	Prepare scintillator tiles
20	Assemble bottom of module
21	Installing fibers into tiles
22	Assemble module top
23	Quality control
24	Module testing
25	1st module finished and tested
26	**CCR Detector Assembly**
27	Prepare scintillator tiles
28	Assemble detector with CPR procedure
29	1st module finished and tested
30	**Fiber Bundles**
31	Assemble WLS fiber pigtails
32	1st WLS fiber bundle finished
33	Design of phototube fixtures and clear fibers
34	Assemble clear fiber bundles
35	Assemble phototube fixtures



J. Huston

Cost Summary

Cost	$740K
Contingency	$205K
Cost+Cont.	$945K
U.S. (with Cont.)	$425K
Japan	$301K
Italy	$168K
Fnal Labor	$51K

Our piece of the $9.1M...

Contingency	$205K
Non-Fnal Labor	$75K
R+D	$56K
Parts	$24K

Cost

CPR2 prototype

- Half of a wedge prototype (built at ANL); can install in Run IIa (with 2 week shutdown)

Summary

- For a relatively modest cost, electron/photon ID, jet energy resolution can be maintained/improved through Run IIb
- Technology is well understood within CDF
- Group within CDF has been formed to work on upgrade including 2 foreign institutions